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Technical Sciences

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The Coordination of the Electrical and Optical Axes
of the Antenna of a Radar Set

by

Engineer Colonel N. Kanonykhin, Candidate of Technical Sciences

The absence of coordination between the electrical and the mechanical axes of the antenna system of the radar set (radiolokatsionnaya stantsiya--RLS) causes a systematic error in the determination of the bearing and angle of target location. To eliminate it, during production, repair, and operation of the RLS it is necessary to check the coordination of the electrical and mechanical axes of the RLS antenna system.

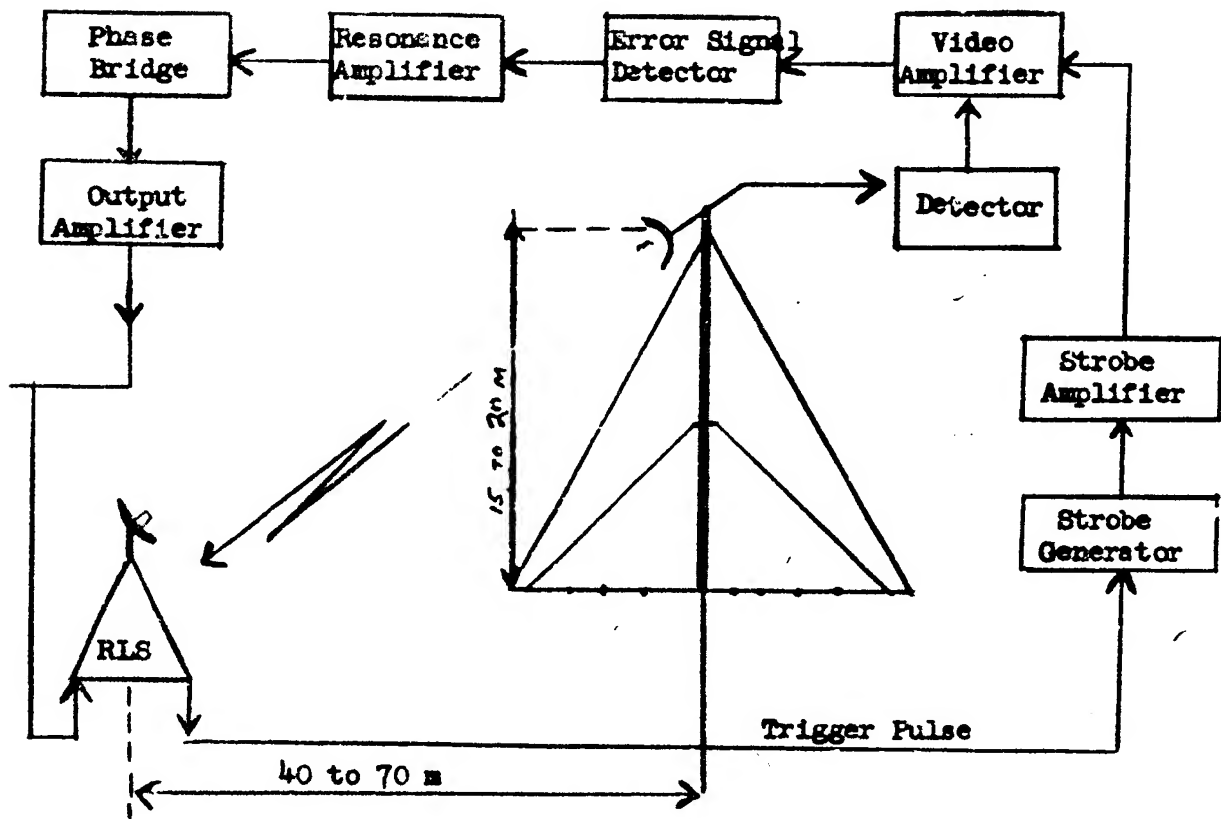
It is impossible to coordinate the electrical and mechanical axes of the antenna system immediately. Therefore, first, with the assistance of appropriate devices, the mechanical axis of the antenna is coordinated with the electrical axis, and then the optical axis is coordinated with the electrical axis.

The optical and electrical axes of the RLS antenna systems that determine the angular coordinates by the equiphase zone method, with the conical lobing of the beam in space, may be coordinated with the aid of a PSO-2 type device.

This device ensures the accuracy of the coordination of the axes with a mean error of $\pm 0-00.5$. The PSO-2 device works on the following principle (see diagram 1).


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DIAGRAM 1Diagram of PSO-2 Device

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At a distance of 40 to 70 meters from the RLS, and at a height of 15 to 20 meters, a PSO-2 antenna with circular polarization is set up. The RLS antenna is pointed toward it.

The high-frequency electromagnetic energy impulses radiated by the RLS are received by the PSO-2 antenna. And if the electrical axis of the RLS antenna system does not coincide with the direction toward the PSO-2 antenna, the impulses that are received will be modulated in amplitude.

The amplitude envelope of these impulses represents a sinusoidal voltage. It has a frequency that is determined by the speed of the antenna head rotation, an amplitude proportional to the size of the angle of error between the electrical axis of the antenna and the direction to the PSO-2 antenna, and also a phase determined by the position of the PSO-2 antenna in the image plane.

The impulses received by the PSO-2 antenna are detected, amplified, and then the discrimination and amplification of the impulse envelope are carried out. This voltage is used as the voltage of the error signal, for which it is relayed directly into the system of automatic tracking (sistema avtomaticheskogo soprov zhdeniya--SAS) of the target in the direction of the RLS (for RLS SON-4, SON-9, to the input of the resonance amplifier).

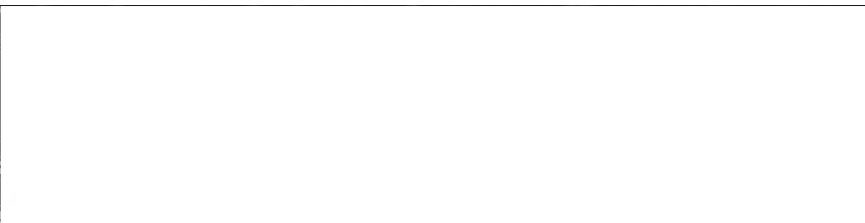
By the advance setting of the PSO-2 phase bridge regulator, the voltage phase of the error signal is set so that at the indicated shut off of the SAS there would be no signal indicating bearing and angle of location in the SAS RLS.

When sending the output voltage of the PSO-2 into the SAS RLS system, the processing of the error signal takes place, and the electrical axis of the RLS antenna system turns out to coincide with the direction to the PSO-2 antenna.

The PSO-2 antenna has a marker that was installed taking the base of the RLS scope (vizir) into consideration. If the cross hairs of the scope coincide with the PSO-2 marker, then the electrical and optical axes of the RLS antenna system are coordinated. If they do not coincide, then by displacing the parabolic reflector this is achieved in the plane of the azimuth, or by displacing the optical axis of the scope, it is done in the plane of the angle of location.

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The basic value of using the PSO-2 is the simplicity of carrying out the operation of coordination and the possibilities of carrying it out irrespective of weather conditions.

However, the utilization of the PSO-2 also has faults, the greatest of which is that during the accomplishment of the operation of coordinating the axes it is necessary to emit high-power, high-frequency energy into space.

It is simpler to carry out the coordination of the axes of the antennas with the help of an EKHO-1 device, which is an ordinary monitoring resonator (diagram 2). It is linked to the antenna by circular polarization which is set up during the coordination of the axes and which corresponds to the PSO-2 antenna.

To reduce the attenuation of the "ringing" signal the high-frequency cable between the monitoring resonator and the antenna is made short (2 to 3 meters), and the tuning of the monitoring resonator is done with the aid of a synchronized signal directly from the operator cab (kabine) of the RLS (the monitoring resonator detector is to be brought into the RLS cab).

The EKHO-1 antenna is RF-ed by the RLS, and at the same time the coordination of the electrical and optical axes of the RLS antenna system is done, using the same method as for the PSO-2. Moreover, the SAS of the RLS target works from the EKHO-1 signal ("ringing" of the monitoring resonator), delineated by the stroke on the range sector where the "ringing" is not saturated and signals reflected from local objects are absent.

The EKHO-1 device may also be used to measure the operating frequency of the transmitter and the klystron of the receiver, to take the frequency spectrum of the impulse being emitted, to evaluate the RLS power drop (according to the magnitude of the "ringing") and others, and also to determine the steepness of the RLS antenna systems' RF performance curve.

Normally the RF performance curve is determined by using a local object for control.

The local control object may be a corner reflector (with an end size of 1 meter) or a metal sheet (of about 2 meters by 2 meters in size), or a local object with an [angular] size of not more than 2.5 d.u.

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[unknown unit of measure, possibly grid azimuth--direktsionnyy ugol], from which the reflected signal does not fluctuate and exceeds the noise level of the RLS system itself by 5 to 10 times.

Other local objects must be located at a slant range of 150 to 200 meters and by angular coordinates not closer than 1-00.

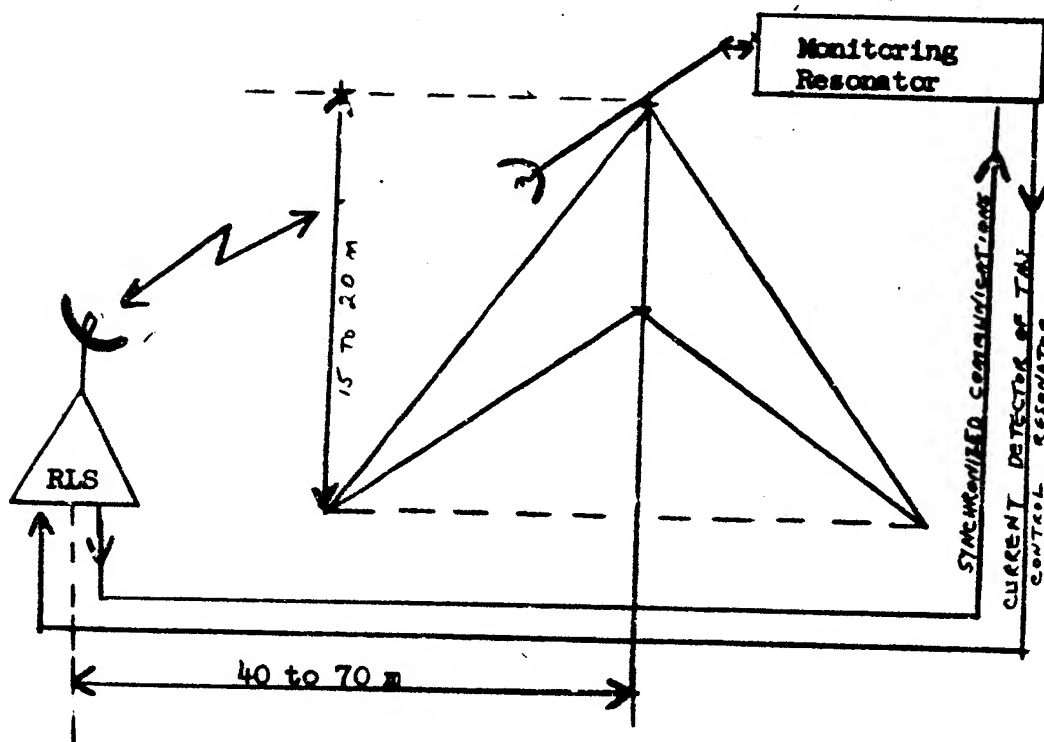


DIAGRAM 2

Diagram of Monitoring Resonator Device (EKHO-1)

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To determine the DF performance curve the RLS antenna is aimed at the local control object. The SAS of the target is switched on for range and direction and the position of the antenna is determined by the dials of the fine receiving selsyn. The electromechanical amplifier (elektromekhanicheskiy usilitel--EMU) is switched on to the angles of elevation (ugol mesta). Then the antenna is manually offset 0-20 to 0-25 from the azimuth of the direction to the local object and the EMU of the azimuth is switched off. The voltage (excitation -- vozbuzhdeniye) at the jacks of the azimuth channel is measured in selecting the mode of operation of the antenna control system when tracking the target automatically.

The indicated operation is carried out through 0-04 to 0-06 up to a 0-20 to 0-25 error in azimuth in the opposite direction from the local control object. Then a graph is drawn showing the dependence of the azimuth EMU excitation voltage (in volts), as a result of the antenna deviation in azimuth from the direction of the DF to the local control object (in small d.u.).

On the straight-line part of the graph the steepness of the DF performance curve is shown in volts per d.u.

The steepness of the DF performance curve is determined by the formula:

$$K_T = K \cdot K_1 = K \frac{U_v}{p}$$

Where U_v - excitation voltage drop between two points of the straight line part of the performance curve.

p - the number of d.u. that lie between the two selected points.

The coefficient K is defined as the relation of the steepness of the DF performance curve, taken for an airplane, to the steepness of the DF performance curve K_1 , taken for the local control point.

The steepness of the DF performance curve is determined at three points of the RLS operating frequency band--the two extreme ones and the middle one.

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When using the EKHO-1 device, the method for reading the steepness of the IF performance curve remains the same. For an RLS of the SON-9a type, the coefficient K fluctuates between 0.8 and 1.1. In this, the EKHO-1 answer signal replaces the reflected signal from the monitoring resonator.

Thus, at the present time, for the purpose of coordinating the electrical and optical axes and determining the IF performance curves of the antenna systems of RLS's of the SON-4, SON-9, SON-15, SON-30 type and of other similar ones, it is advisable to use the monitoring resonator that is an accessory of these stations.

For this it is necessary:

--to replace the antenna of the monitoring resonator that has linear polarization with an antenna that has circular polarization;

--to provide the opportunity to install the monitoring resonator at a height of 15 to 20 meters (it is best to use the antenna and mast of a P80-2 set for this purpose).

Besides this, it is desirable to ensure the possibility of tuning the monitoring resonator from the operator cab of the RLS, and for this, between the monitoring resonator and the RLS, it is necessary to install synchronized communications and bring the microammeter of the monitoring resonator into the cab of the RLS.

Under these conditions the operation of checking the coordination of axes and reading the IF performance curve in the field can be done by the personnel of the RLS crew in 20 to 25 minutes irrespective of weather conditions. The above-mentioned alterations of the regular monitoring resonator that is an accessory of all the listed radar stations are easily carried out by the personnel and equipment of the KRAS.

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